Enhancement of Visual Transparency and Photocurrents in Semi-Transparent Perovskite Solar Cells by Electrode-Coupled Plasmons

Gyu Min Kim, Tetsu Tatsuma

Institute of Industrial Science, The University of Tokyo

E-mail: gyumin@iis.u-tokyo.ac.jp

Because of the structural similarities to organic solar cells (OSCs), techniques for preparation of semi-transparent OSCs[1,2] can also be applied to perovskite solar cells (PVSCs). However, the reports regarding semi-transparent PVSCs are relatively scarce compared to semi-transparent OSCs because of high absorption coefficient of perovskite layers, which prevent good transparency. Although the use of thinner perovskite layers might improve the transparency, the power conversion efficiency (PCE) is inevitably decreased due to the reduced light absorption.

Here, we developed high-performance semi-transparent PVSCs with thin perovskite layers by exploiting plasmon couplings between silver nanocubes (AgNCs) and a thin semi-transparent silver electrode as electrode-coupled plasmons (ECPs).[3] We tuned the characteristics of ECPs by a finite-difference time-domain (FDTD) method so as to achieve strong near field and far field scattering in a deep red range, where photosensitivity of human eyes is relatively low. Figure 2 shows a slight decrease in transmittance of a PVSC[4] with AgNCs due to the enhancement of light absorption by ECPs. However, the reduced transmittance does not largely affect the visual transparency of the PVSCs (insets of Figure 2) because the increase in transmittance is mostly in the deep red region. Further, the PVSCs with ECPs exhibit higher PCEs of 9.73 ± 0.12% while the value of the cell without ECP is 8.62 ± 0.24%. In conclusion, the application of ECPs to semi-transparent PVSCs realizes high PCE and transparency simultaneously, making them a promising candidate for the next generation of semi-transparent photovoltaic cells.

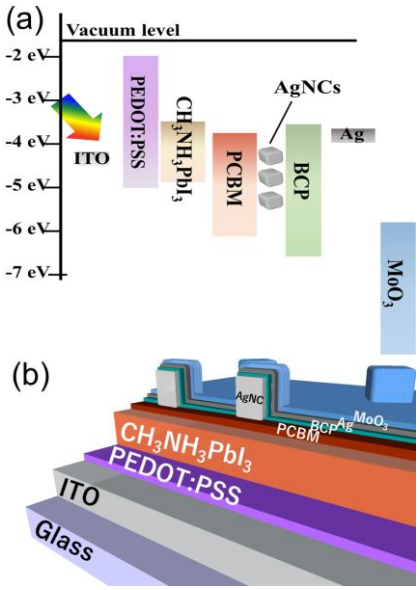

Figure 1. (a) The energy diagram and (b) the structure of semi-transparent PVSCs with ECPs.

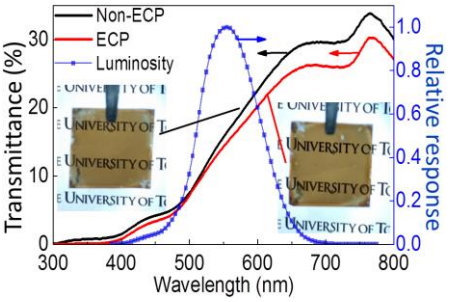

Figure 2. Transmittance of semi-transparent PVSCs without ECP and with ECPs and the luminosity curve. The insets are actual PVSCs.

References

[1] Van De Lagemaat, J. *et al. Appl. Phys. Lett.* **88**, 233503 (2006).

[2] Wu, J. *et al. Appl. Phys. Lett.* **92**, 237 (2008).

[3] Kim, G. M. & Tatsuma, T. *J. Phys. Chem. C* **121**, 11693 (2017).

[4] Kim, G. M. & Tatsuma, T. *J. Phys. Chem. C* **120**, 28933 (2016).